

Identification of *Pyrrhosoma elisabethae* with notes on its distribution and habitat (Odonata: Coenagrionidae)

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ABSTRACT

Pyrrhosoma elisabethae is one of the rarest and least known odonate taxa in Europe and is often considered to be a subspecies of *P. nymphula*. The taxon is known from eight localities, four on the Peloponnisos, Greece, three on Kérkira (Corfu), Greece, and one in southern Albania. We describe structural differences between *P. elisabethae* and *P. nymphula* in both males and females, and present a key that distinguishes these two taxa. These structural differences, combined with the lack of intermediates, suggests that *P. elisabethae* should be treated as a full species. Notes on habitat associations and flying season of *P. elisabethae* are also given.

INTRODUCTION

For most European Odonata, the distributional range is largely known and detailed information on habitat and ecology is available. One of the few exceptions is *Pyrrhosoma elisabethae* Schmidt, 1948. This species is, at first glance, almost identical to *P. nymphula* (Sulzer, 1776); a spring species common in large parts of Europe. Schmidt (1948) distinguished *P. elisabethae* from *P. nymphula* using a number of diagnostic morphological characters, and a number of less reliable characters which vary in both species or are merely correlated with the colour morphs of the females. Based on these latter characters, 'intermediate' specimens were described by Buchholz (1954), Stark (1979) and Ottolenghi (1991). In addition, Varga (1968) described *P. nymphula interpositum*, an intermediate between *P. elisabethae* and *P. nymphula*.

All this led to confusion about the distribution and taxonomic status of *P. elisabethae*. The taxon is most often considered to be a subspecies of *P. nymphula* (e.g. Davies & Tobin 1984; Bridges 1994; Tsuda 2000; Wasscher & Bos 2000) with intermediates occurring as far north as Austria (Askew 1988).

In this study we describe the diagnostic structural characters of *P. elisabethae* and *P. nymphula*, and we present a key that distinguishes these species. Specimens previously classified as 'intermediate' are reinterpreted. The distribution, habitat and phenology of *P. elisabethae* are also outlined.

MATERIAL AND METHODS

The characters used by Schmidt (1948) in the original description of *Pyrrhosoma elisabethae* were tested on series of *P. nymphula* from Albania, France, Greece, Macedonia, Montenegro, the Netherlands and Turkey, and on specimens of *P. elisabethae* from Greece and Albania. Specimens were examined from the following collections:

DEI	Deutsches Entomologisches Institut, Müncheberg, Germany
ISNB	Institut Royal des Sciences Naturelles, Brussels, Belgium
RMNH	Nationaal Natuurhistorisch Museum Naturalis, Leiden, The Netherlands
ZFMK	Zoologisches Forschungsinstitut und Museum Alexander Koenig, Bonn, Germany
WL	Personal collection of Wolfgang Lopau

The series of *P. elisabethae* included 18 males and 10 females constituting all specimens present in the RMNH, ZFMK, and WL collections; including one male and one female of the type series from RMNH (see Table 1).

The following specimens of *P. nymphula* (present in RMNH unless otherwise stated) were examined: — Albania: 1 ♀, Bizë at Shëngjergji, alt. 1,400-1,500 m, 10-15 vii 1961, leg. Albanien-Expedition 1961 DEI, in coll. DEI; 3 ♂, 2 ♀, Bënçe, 10-21 v 2001, leg. B. Achterkamp, A. and M. Hospers; 1 ♂, Gjirokastër, Viroi, karstic spring, 22 v 2001, leg. B. Achterkamp, A. and M. Hospers. — France: 6 ♂, 3 ♀, Bretagne, Pont l'Abbé, 07 vi 1969, leg. Leidse Biologen. — Greece: 1 ♂, Makedhonia, Thessaloniki, near bridge 3 km WNW of Kato Stavros, river between Limni Vólvi and the sea, alt. 0-50 m, 22 vi 1984; 2 ♂, 2 ♀, Thessalia, Larissa, permanent and unshaded brook 1 km S of Spiliá, alt. 500-1,000 m, 20 vi 1984; 1 ♂, Makedhonia, Khalkidhiki, 8 km ENE of Arnaia, brooklet E of Neohóri, alt. 400 m, 22 vi 1984; 4 ♂, 5 ♀, Thessalia, Tríkala, 23 km W of Tríkala, mountain brooklet 6 km ENE of Pertoúli, alt. 1,200-1,300 m, 26 vi 1984; 3 ♂, 3 ♀, Thessalia, Tríkala, 26 km W of Tríkala, mountain brooklet 3 km NE of Pertoúli, alt. 1,100-1,200 m, 26 vi 1984; 2 ♂, 3 ♀, Thessalia, Larissa, permanent and shaded brook 6 km NE of Spiliá, alt. 700 m, 20 vi 1984; 1 ♂, Makedhonia, Katerini, upper course of Petriotikos rivulet ca. 29 km SW of Katerini, alt. ca. 800-900 m, 16 vi 1984; 1 M, Makedhonia, Kozáni, 22 km WSW of Kozáni, Aliákmon river between Greaná and Kozáni near bridge, alt. 500 m, 28 vi 1984 – all Greek specimens leg. H. Mol, G.J. van Pelt and J. van Tol. — Macedonia: 10 ♂, 2 ♀, Lake Ohrid, close to the Hydrobiological Institute, 24/25 v 1983, alt. 700 m, leg. Thomas and Adema. — Montenegro: 3 ♂, 2 ♀, Bijelo Polje, 6 vi 1960, leg. P.R. and C.L. Deeleman. — The Netherlands: 3 ♂, 1 ♀, Noord-Holland, Bloemendaal, Duin en Kruidberg, v 2001, leg. V.J. Kalkman. — Turkey: 1 ♀, Bolu, 14 km S of Bolu, spring 1 km W of lake Gölcük at ca. 8 km S of Karacasu, alt. 1,200 m, 20 vii 1998, leg. G.J. van Pelt; 1 ♂, Bolu, 4 km WSW of Bolu, SE outlet of barrage Lake Gökçöy, alt. 700 m, 27 vi 1999, leg. G.J. van Pelt; 2 ♂, Bolu, ditch along road to Karacasu, 3 km S of Bolu, alt. 700 m, 08 vi 2003, leg. A. Kop; 1 ♂, 1 ♀: Bolu, marshy field at N shore of Abant Gölü, 1,400m, 09 vi 2003, leg. A. Kop; 2 ♂, Bolu, NE shore of Abant Gölü, alt. 1,400 m, 09/27 vi 2003, leg. A. Kop; 1 ♂, Düzcé, (Bolu) ca 17 km NNE of Mudurnu, brook on Sinek yayla 5 km NE of Abant Gölü, alt. 1,450 m, 28 vii

Table 1. Overview of all known records of *Pyrrhosoma elisabethae*.

Location	Date	♂	♀	Deposition	Source/leg.
ALBANIA					
Kaltërt ('blue spring'): powerful spring complex, forming the Bistrica River (39°54'N, 20°12'E)					
	05 vi 1993	4	1	Coll. H.J. Dumont	Dumont et al. (1993)
Syrri Kaltërt (at Reçe) (39°55'N, 20°11'E)					
	24 v 2001	1	-	RMNH	leg. B. Achterkamp, A. & M. Hospers
GREECE					
Kérkira (Corfu)					
		-	1	ISNB (coll. Selys)	Schmidt (1954)
Kérkira (Corfu)					
	21 iv 1961	4	1	ZFMK	leg. J. Niethammer
Kérkira (Corfu), marsh at Gouviá (39°3'N, 19°5'E)					
	20 v 1998	1	-	Coll. W. Lopau	leg. W. Lopau
Kérkira (Corfu), Pérama					
	01 v 1978	1	-	RMNH	Hämäläinen (1983)
Kérkira (Corfu), Pérama					
	31 v 1981	1	-	RMNH	Hämäläinen (1983)
Kérkira (Corfu), river 2 km SSE Sidári (39°4'N, 19°4'E)					
	23 v 1998	3	1	Coll. W. Lopau (1♂)	leg. W. Lopau
Peloponnisos, brook 1 km W of Kalávrta (38°0'N, 22°0'E)					
	01-02 vi 1998	>50 observed		Coll. W. Lopau (4♂, 4♀)	Lopau (1999)
Peloponnisos, brook 1 km W of Kalávrta (38°0'N, 22°0'E)					
	18 vi 1999	1	1	Coll. W. Lopau	Lopau (2000)
Peloponnisos, Kalávrta (38°2'N, 22°6'E)					
	06 vi 2003	common		Coll. G. Jacquemin (2♂, 2♀)	leg. J.-P. Boudot ¹
Peloponnisos, brook 2 km N of Dháfni (37°4'N, 22°0'E)					
	03 vi 1998	> 20 observed		Coll. W. Lopau	Lopau (1999)
Peloponnisos, brook 7 km SW of Kalávrta (37°5'N, 22°0'E)					
	02 vi 1997	2	1	Coll. W. Lopau	Lopau (1999)
Peloponnisos, Kalávrta					
	27-29 v 1939	28	14	1♂, 1♀ in RMNH	Schmidt (1948)
Peloponnisos, Kalávrta					
	31 v 1959	1	-	ZFMK	leg. K.F. Buchholz
Peloponnisos, Kalávrta					
	12 v 1959	4	2	ZFMK	leg. K.F. Buchholz

¹ Plate IVa

2003, leg. G.J. van Pelt; 5 ♂, Sakarya, ca. 10 km NNW of Pamukova, pools and spring just NE of Eski Yayla Köy, alt. 1,000 m, 26 vi 2004, leg. G.J. van Pelt.

We did not examine the 'transitional' specimens described by Buchholz (1954), Stark (1979) and Ottolenghi (1991) nor the holotype and paratypes of *P. n. interpositum* (cf. Varga 1968).

RESULTS

Both sexes of *Pyrrhosoma elisabethae* can be easily distinguished from *P. nymphula* based on morphological characters already defined in its original description. The most useful characters for discriminating these species are the male appendages and the female prothorax:

1. Male: The ventral branch of the superior appendages is approximately one third the length of the dorsal branch (Fig. 1a). The inferior appendages extend beyond the superior appendages (Fig. 1a). Female: The hind margin of the pronotum has a deep and raised fold on each side; these folds are prominent in both lateral and dorsal views (Fig. 1b) *elisabethae*

1'. Male: The ventral branch of the superior appendages is about two-thirds the length of the dorsal branch (Fig. 1d). The inferior appendages are normally as long as or shorter than the superior appendages (Fig. 1d). Female: The hind ridge of the pronotum contains only slight kinks on the hind margin; these are not raised above the margin in lateral view (Fig. 1e) *nymphula*

DISCUSSION

Differentiation between *Pyrrhosoma elisabethae* and *P. nymphula*

Both species are medium-sized zygopterans that are easily separated from other European species by their predominantly red abdomen, yellow or red antehumeral stripes, and black legs (Plate IV). Some females have a primarily black abdomen with yellow markings.

The key to the species of *Pyrrhosoma* given in the original description of *P. elisabethae* (Schmidt 1948) includes a larger number of characters. We found that some of these characters, such as the presence or absence of a brownish stripe on the tibia of the hindlegs and the colour of the styli, varied within the species or were related to age or the colour morphs of the females. These characters are unreliable and should not be used to distinguish these taxa. Female colour pattern is also ambiguous and is not a reliable character for identification. In both *P. elisabethae* and *P. nymphula* females, the abdomen may be red with black markings or black with yellow markings.

The metasternum is also potentially ambiguous. *P. elisabethae* has an extensive black pattern with three well-defined, almost round, yellow spots. Typically, *P. nymphula* has a largely yellow metasternum. However, some *P. nymphula* have a more extensive black pattern on the metasternum that resembles *P. elisabethae* (see also Liefstinck 1966). Therefore this character should only be used as a first indication. Also, it should be noted that the description and figure from the female pronotum given by Askew (1988: 74, figure 68) is not correct; they are based on a wrong interpretation of the figure in the original description (Schmidt 1948).

The morphology of the penis is almost identical in both species. A slight difference has been found with regard to the setae on the penis shaft (Fig. 1c, f). In *P. nymphula* we found 10 setae, which are roughly in line with the longitudinal

axis of the shaft. In *P. elisabethae* we found eight setae, most of which go off at an angle of more than 45° with the longitudinal axis of the shaft. However these differences are only based on one specimen of each species.

Intermediate specimens and subspecies *Pyrrhosoma nymphula interpositum*

Buchholz (1954), Stark (1979) and Ottolenghi (1991) described putative transitional forms between *P. elisabethae* and *P. nymphula*. Buchholz (1954) collected two males and one female from Gorgopotamos. The males were almost identical with *P. nymphula*, but the ventral branch of the superior appendages were only slightly longer than half the length of the dorsal branch. Intermediate characters he observed in the female were a more extensive black design on the abdomen and the absence of red on the thorax.

Stark (1979) checked 116 males and 35 females from the Steiermark, Austria. He based his transitional forms on three characters: (1) seven females had a more or less extensive black design on the abdomen; (2) nine females had only a yellow and black pattern on the thorax with no trace of red; and (3) in 27 males the inferior appendages were as long as the superior appendages, while in another two the inferior appendages were somewhat longer than the superior appendages.

Ottolenghi (1991) described one male and two females of *Pyrrhosoma* from Rendina, central Greece, as "*P. n. nymphula* trans ad *P. n. elisabethae*". The male was morphologically identical to *P. nymphula*, except the metafemora were dark-brown. The females were also structurally similar to *P. nymphula* but were closer in coloration to *P. elisabethae*.

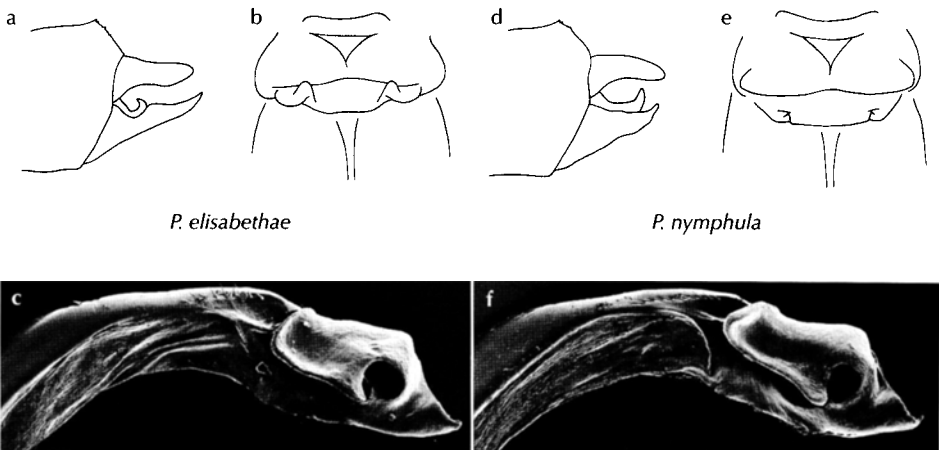


Figure 1: Differentiation characters between *Pyrrhosoma elisabethae* and *P. nymphula* — (a, d) male anal appendages, lateral view; (b, e) female pronotum, dorsal view; (c, f) SEM photograph of distal portion of the penis, lateral view. (a-c) *P. elisabethae*, Peloponnisos, brook 1 km W of Kalávritá; (d-f) *P. nymphula*, The Netherlands, Bloemendaal, Duin en Kruidberg.

P. nymphula interpositum was described as an intermediate between *nymphula* and *elisabethae*, with specimens from Zemplén Mountains, Bükk Mountains and Bakony Mountain, Hungaria, and Durmitor Mountains, Montenegro (Varga 1968). Varga (1968) argued that the males could be distinguished from the nominate subspecies based on (1) the broader hind ridge of the pronotum, (2) the longer, more robust and less curved prophallus, and (3) the anal appendages being intermediate between *elisabethae* and *nymphula*. The superior appendages were described as having a ventral branch of slightly less than 2/3 of the length of the dorsal branch. The inferior appendages were described to be about as long or slightly longer than the superior appendages.

The characters on which Buchholz (1954), Stark (1979), Ottolenghi (1991) and Varga (1968) based their claim for 'intermediate' specimens and an 'intermediate' subspecies, respectively, primarily refer to the coloration of the females and the appendages of the males. In his original description of *P. elisabethae*, Schmidt (1948) used female coloration in the key to the species. This led to the belief that female coloration could serve as a distinguishing character. However, as stated above, the differences in female coloration occur in both species and thus cannot be used to separate the taxa. The differences in the male appendages refer to the length of the inferior appendages and the length of the ventral branch of the superior appendages in relation to the dorsal branch. However, the described variation is still clearly far closer to the characters of *P. nymphula* than that of *elisabethae* and merely shows that there is some variation within *P. nymphula*. Furthermore none of the female specimens showed intermediate structural characters with regard to the hind margin of the pronotum. Another argument against the hypothesis of existing intermediates is the fact that a population of *P. nymphula* occurs in Albania, which does not show any indication of intergression, although there is less than 25 km distance to a population of *P. elisabethae*. This leads us to the conclusion that the 'intermediate' specimens are based on small regional differences within *P. nymphula*. Whether or not the establishment of the subspecies *interpositum* was justified is outside the scope of this paper.

Distribution

Figure 2 gives the distribution of both species in the southern Balkans, where *P. elisabethae* is one of the few odonate species endemic to Europe (Sahlén et al. 2004). All its records known so far are presented in Table 1. The specimens collected by Schmidt (1954), Hämäläinen (1983) and Dumont et al. (1993) were not seen by us but are believed to be correctly identified. No details are known of three of the records from the Peloponnisos and two of the records from Corfu. Therefore, in total only eight different localities for the species are known for certain: four on the Peloponnisos, Greece, three on Kérkira (Corfu), Greece, and one in southern Albania. The description of the type locality of *P. elisabethae* is brief: "Kalávrita, Nord-Peloponnes, ca. 750 m über Meereshöhe". It is therefore not certain whether one of the localities found by Lopau (1999a) pertains to the type locality.

All Greek records of *Pyrrhosoma* made by WL outside the Peloponnisos and Corfu were carefully identified and belonged to *P. nymphula* (Lopau 1999b, 2000). Also all Greek specimens present in the RMNH (van Pelt 1999) collected outside

the Peloponnisos and Corfu were found to belong to *P. nymphula*. The record from the Greek province of Makhedonía given by Galletti & Pavesi (1983) belongs to *P. nymphula* as can be clearly seen from their illustration of the male appendages. We did not see specimens of other records of *Pyrrhosoma* from Greece, so we can not be sure about their identity.

Both Albanian records of *P. elisabethae* are from the same locality. On the four other records of *Pyrrhosoma* from Albania three pertain to *P. nymphula*, all lying in the eastern, more mountainous, part of the country. We saw the male from Borshi south of Vlore mentioned in Bilek (1966) and present in DEL, but it could not be identified as the appendages are missing.

In Turkey, the genus *Pyrrhosoma* is known from 12, partly unpublished, localities. The seven we saw, all from the northwest of the country, belong with certainty to *P. nymphula*. We did not see material from the two records of *P. nymphula* published by Hacet & Aktaş (1997) and by Morton (1922), all from NW Turkey. Specimens from Belgrade forest near Istanbul (Asiatic side) are depicted in Schneider (1986). The inferior appendages of the depicted male are longer than the superior appendages. However, the ventral branch of the superior appendages is

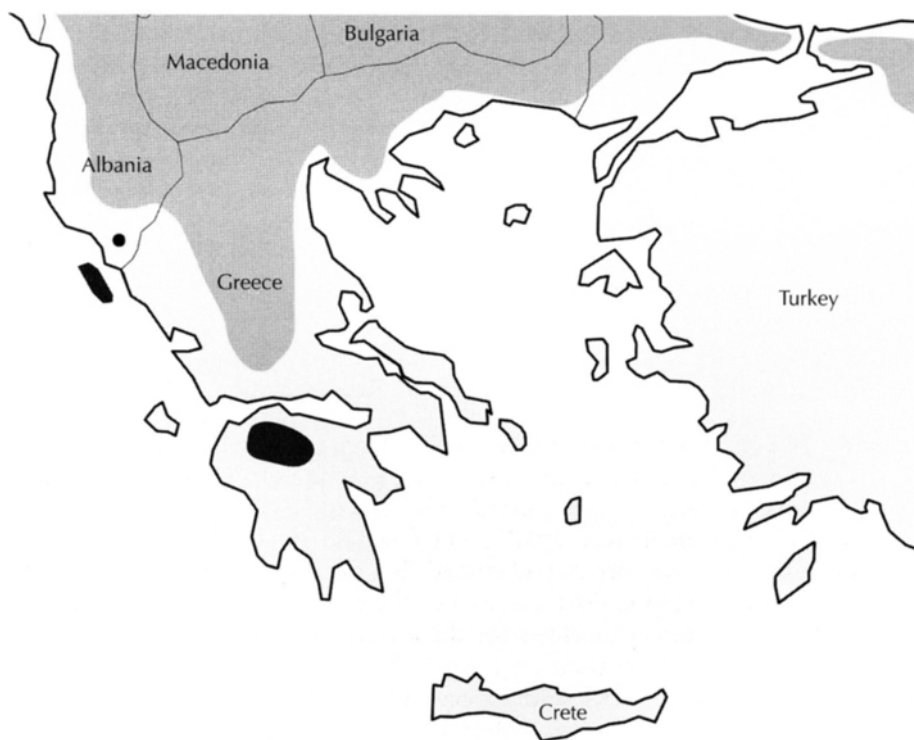


Figure 2: Distribution of *Pyrrhosoma elisabethae* (black) and *P. nymphula* (dark grey) in the southern part of the Balkans.

about two-third the length of the dorsal branch, so it is clearly *P. nymphula*. Selys (1887) published a record of *P. nymphula* (as *P. minium*) from Iskenderun (Dumont 1977). However the identity of this specimen could not be checked and the record is doubted as it lies outside the known range of the genus in a region where the species is not expected to occur.

No records of *P. elisabethae* are known from the former Yugoslavia and Bulgaria. But probably not all published records of *Pyrrhosoma* from there have been properly checked.

With only eight localities known, *P. elisabethae* is one of the least known and rarest European odonates. As far as we know, none of the localities are protected. One of the sites – Peloponnisos, brook 7 km SW of Kalávrita – was re-visited by WL in 1998, a year after the species was first found at that locality (Table 1). At that time the brook had been reconstructed and lacked vegetation. Although a stretch of 1 km was searched, no specimen of *P. elisabethae* was found. In 2004, the brook was vegetated again but *P. elisabethae* was still absent (WL unpubl.). This demonstrates the vulnerability of its habitat.

P. elisabethae is probably present in NW-Greece, as it was found in Albania less than 20 km from the Greek border. In the south of Albania the distance between its occurrence at Kaltërt and the occurrence of *P. nymphula* at Gjirokastër (Albania) is less than 25 km. It seems likely that the ranges of both species overlap in this part of Albania, and the species might even co-occur. Dumont et al. (1993) suggest that *P. elisabethae* is “restricted to a hot Mediterranean coastal zone, with possibly a wider distribution on the Peloponesos [Peloponnisos] only”. More field-work in Albania and NW-Greece is needed to test this statement.

Habitat and flying season

Information on the habitat of *P. elisabethae* is mainly based on observations made by WL (Table 1). In the coastal plains of Kérkira it was found in a ditch and along a slow flowing river, accompanied by species such as *Coenagrion pulchellum* (Vander Linden), *Platynemis pennipes nitidula* (Brullé), *Aeshna isoceles* (Müller) and *Libellula fulva* Müller. In the mountains of the Peloponnisos the species was found at brooklets with clear, cool water and rich vegetation. Here it co-occurred with species as *Calopteryx splendens balcanica* Fudakowski, *Calopteryx virgo festiva* (Brullé), *Coenagrion ornatum* (Selys), *Coenagrion puella* (Linnaeus) and *Caliaeschna microstigma* (Schneider). Oviposition took place in tandem in grasses, sedges and plantain (*Plantago* sp.) just above or beneath the water surface. The record by J.-P. Boudot (Table 1) was made at a well-vegetated brook where it co-occurred with *C. splendens balcanica*, *C. virgo festiva*, *C. puella* and *Ischnura elegans* (Vander Linden). Although the species has only been found at running waters so far, it seems likely that it, like *P. nymphula*, can be found at well-vegetated standing waters as well.

The known records all date from spring and early summer, between 21 April and 18 June. Copulations were noted on 23 May 1998 and on 1-3 June 1998, oviposition on 2-3 June 1998. It seems likely that its flying season is more or less the same as its relative *P. nymphula*. If this is true *P. elisabethae* is probably already on the wing at the end of March.

CONCLUSIONS

Pyrrhosoma elisabethae is most often considered to be a subspecies of *P. nymphula* (e.g. Davies & Tobin 1984; Askew 1988; Bridges 1994; Tsuda 2000; Wasscher & Bos 2000). However, we argue that it should be considered a full species, because both males and females show clear, well-defined morphological differences and because there is no transition zone between taxa.

Information on distribution and habitat of this species is scant, therefore research is urgently required. *P. elisabethae* might be the most threatened of all odonate species occurring in Europe.

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REFERENCES

- Askew, R.R., 1988. The dragonflies of Europe. Harley, Colchester.
- Bilek, A., 1966. Ergebnisse der Albanien-Expedition 1961 des Deutschen Entomologischen Institutes. Odonata. Beiträge zur Entomologie 16: 327-346.
- Bridges, C.A., 1994. Catalogue of the family-group, genus-group and species-group names of the Odonata of the world (third edition). Bridges, Urbana.
- Buchholz, K.F., 1954. Zur Kenntnis der Odonaten Griechenlands. Bonner Zoologische Beiträge, Sonderband 1954: 51-71.
- Davies, D.A.L. & P. Tobin, 1984. The dragonflies of the world: a systematic list of the extant species of Odonata. Vol. 1. Zygoptera, Anisozygoptera. Societas Internationalis Odonatologica Rapid Communications (Supplements) 3: i-ix, 1-127.
- Dumont, H.J., 1977. A review of the dragonfly fauna of Turkey and adjacent Mediterranean islands (Insecta: Odonata). Bulletin et Annales de la Société Royale d'Entomologie de Belgique 113: 119-171.
- Dumont, H.J., J. Mertens & A. Miho, 1993. A contribution to the knowledge of the Odonata of Albania. Opuscula Zoologica Flumensia 113: 1-10.
- Galletti, P.A. & M. Pavesi, 1983. Su alcuni Odonati di Grecia. Giornale Italiano di Entomologia 1: 247-260.
- Hacet, N. & N. Aktaş, 1997. Odonata fauna of Istranca Mountains. Turkish Journal of Zoology 21: 275-289 [In Turkish; English summary].
- Hämäläinen, M., 1983. Additions to the knowledge of the odonate fauna of the Island of Corfu, Greece. Notulae Odonatologicae 2: 25-26.
- Lieftinck, M.A., 1966. A survey of the dragonfly fauna of Morocco (Odonata). Bulletin Institut Royal des Sciences Naturelles de Belgique 42: 1-63.
- Lopau, W., 1999a. Bemerkenswerte Libellenfunde aus Griechenland. Libellula, Supplement 2: 63-66.

- Lopau, W., 1999b. Bisher unveröffentlichte Libellenbeobachtungen aus Griechenland. *Libellula*, Supplement 2: 91-131.
- Lopau, W., 2000. Bisher unveröffentlichte Libellenbeobachtungen aus Griechenland II (Odonata). *Libellula*, Supplement 3: 81-112.
- Morton, K.J., 1922. Further notes on the Odonata of Constantinople and adjacent parts of Asia Minor. *Entomologist* 55: 80-82.
- Ottolenghi, C., 1991. Contributo alla conoscenza degli odonati di Grecia. *Bollettino del Museo Civico di Storia Naturale Verona* 15 (1998): 231-242.
- Sahlén, G., R. Bernard, A.C. Rivera, R. Ketelaar & F. Suhling, 2004. Critical species of Odonata in Europe. In: Clausnitzer, V. & R. Jödicke (eds) "Guardians of the watershed. Global status of dragonflies: critical species, threat and conservation". *International Journal of Odonatology* 7: 385-398.
- Schmidt, E., 1948. *Pyrrhosoma Elisabethae* n. sp., eine neue Odonatenart aus Griechenland. *Opuscula Entomologica* 13: 69-74.
- Schmidt, E., 1954. Die Libellen Irans. *Sitzungsberichte der Akademie der Wissenschaften, Wien* 163: 223-260.
- Schneider, W., 1986. Systematik und Zoogeographie der Odonata der Levante unter besonderer Berücksichtigung der Zygoptera. Dissertation, Johannes-Gutenberg-Universität Mainz.
- Selys-Longchamps, E. de, 1887. Odonates de l'Asie mineure et révision de ceux des autres parties de la faune paléarctique (dite Européenne). *Annales de la Société Entomologique de Belgique* 31: 1-85.
- Stark, W., 1979. Mischformen von *Pyrrhosoma n. nymphula* (Sulzer, 1776) und *P. n. elisabethae* Schmidt, 1948 aus der Steiermark, Oesterreich (Zygoptera: Coenagrionidae). *Notulae Odonatologicae* 1: 61-62.
- Tsuda, S., 2000. A distributional list of world Odonata. Tsuda, Osaka.
- van Pelt, G.J. 1999. On dragonflies from Greece in the RMNH collection, Leiden, The Netherlands. *Libellula*, Supplement 2: 77-90.
- Varga, Z., 1968. Eine neue Unterart von *Pyrrhosoma nymphula* Sulz. aus Südost-Europa. *Acta Biologica Debrecina* 6: 187-204. [In Hungarian; German summary].
- Wasscher, M.A. & F.G. Bos, 2000. The European dragonflies: notes on the checklist and on species diversity. *Odonatologica* 29: 31-43.